

Seat No.: _____

Enrolment No. _____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- VIth SEMESTER-EXAMINATION – MAY- 2012

Subject code: 160503

Date: 15/05/2012

Subject Name: Process Equipment Design I

Time: 10:30 am – 01:00 pm

Total Marks: 70

Instructions:

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.

Q.1 (a) Carbon dioxide is to be conveyed from the top of the stripper of ammonia plant to urea plant. Calculate the pipe size required based on following data. **10**

- (i) Flow rate of CO₂ = 1000 t/day
- (ii) Total length of pipe = 800 m
- (iii) Available pressure at inlet of pipe = 24 kPa g
- (iv) Discharge pressure of CO₂ from pipe required = atmospheric
- (v) No. of butterfly valve in pipeline = 1
- (vi) No. of 90° elbows in pipeline = 8
- (vii) Temperature of gas = 60°C
- (viii) Viscosity of CO₂ gas = 0.016 cP
- (ix) Equivalent number of velocity heads for butterfly valve = 0.24
- (x) Equivalent number of velocity heads for 90° elbows = 0.75
- (xi) MOC of Pipe = Carbon Steel

Pipe Size	ID of Std. Pipe
500 mm NB	387.55 mm
600 mm NB	438.15 mm
500 mm NB	488.95 mm
600 mm NB	590.55 mm

(b) For the specified location of the pump calculated value of (NPSH)_A is coming less than (NPSH)_R. Suggest all possible solutions to make (NPSH)_A greater than (NPSH)_R. **04**

Q.2 (a) Discuss in detail about Tinker's flow model for shell side flow in shell & tube heat exchanger. **07**

(b) Discuss the Process design of Horizontal and Vertical Settlers in details. **07**

OR

- (b) Design a suitable decanter to separate oil from water.

07

	Oil	Water
Flow rate, kg/hr	2000	5000
Density (kg/ m ³)	900	1000
Viscosity ,cP	30	1

Assume:- i) Dispersion band = 10%

ii) Droplet size = 175 μm

Use following equation to find droplet velocity,

$$U_d = \frac{[d_d^2 g (\rho_d - \rho_c)]}{18 \mu_c}$$

Q.3

A horizontal shell & tube condenser is to be designed to condense 3.2 kg/s of isobutane at 8.3 kg/cm². Water available at 25°C is to be used in another process unit at 37°C. Tubes of 15 mm inside diameter & 2 mm wall thickness are available. Maximum lengths of the tubes are 4 m. The tubes are to be arranged on 25 mm square pitch.

14

Fouling resistance on each side = 0.0004 m²k/W. Condensation temperature of isobutane = 64°C. Latent heat of condensation of isobutene = 275 KJ/kg. Overall heat transfer for condensing isobutene vapor ranges from 390 to 500 W/m²K. Water velocity should not exceed 3m/s and not to below 0.5 m/s. Thermal conductivity of material = 16 W/m²k. Assume isothermal condensation.

Physical Properties of isobutane:-

$$K = 0.26 \text{ W/m K}, \rho = 1080 \text{ kg/m}^3, \mu = 0.00477 \text{ kg/m s}$$

Physical Properties of Water:-

$$K = 0.62 \text{ W/m K}, \rho = 1000 \text{ kg/m}^3, \mu = 0.00072 \text{ kg/m s},$$

$$C_p = 4.1868 \text{ kJ/kg } ^\circ\text{C}$$

$$\text{Friction factor } f = 0.046 \text{ Re}^{-0.2}$$

Data for bundle diameter calculation: for Square pitch arrangement.

No. of Pass	1	2	4	6	8
k	0.215	0.156	0.158	0.0402	0.0331
n	2.207	2.291	2.263	2.617	2.643

Design a suitable condenser.

OR

- Q.3 (a) Discuss the Advantages and disadvantages of plate heat exchanger over shell and tube heat exchanger. 07
- (b) Discuss the criteria of selection and advantages and disadvantages in between kettle type reboiler and Thermosyphon reboiler. 07

- Q.4** Explain and write all equations involved in following condition for sieve tray tower. **14**
- Pressure drop across tray tower
 - Checking of weeping condition
 - Checking of Down comer flooding
 - Checking of liquid entrainment

OR

- Q.4 (a)** Discuss criteria of selection among the different types of trays used in tray tower. **06**
- (b)** A saturated liquid consisting of Chloro methanes is fractionated to give a top product of 99.94% (by mole) methyl chloride. Methyl chloride is light key and methylene chloride is heavy key component. Total condenser is used. The compositions of the top product and of the methyl chlorides in the residues are given. **08**

Component	α_{av}	Feed, mole %	Distillate mole %	Residue mole %
Methyl chlorides	5.9163	73.7	99.94	0.94
Methylene chloride	1	20.4	0.06	?
Chloroform	0.502	4.7	--	?
Carbon tetrachloride	0.32	1.2	--	?

- Complete the material balance over the still for a feed rate of 100 kmol/hr.
- Calculate the minimum reflux ratio by Underwood's method.

- Q.5 (a)** Design a cap type packing support for packed tower type absorber based on following data. **07**
- Type of packing = 25 mm polypropylene pall ring
 % free area for this packing = 90 %
 Liquid flow rate = 3500 kg/hr
 Density of liquid = 1000 kg/m³
 Tower diameter = 540 mm

- (b)** Discuss the different types of packing support used with packed tower. **07**

OR

- Q.5 (a)** Discuss the criteria of selection among the different types of the equipment used as absorbers or scrubbers. **07**
- (b)** Discuss about the different flow pattern of liquid in column with neat sketch. **07**
